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Puha

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(54) **GAS-DELAYED BLOWBACK OPERATING SYSTEM AND METHOD FOR AR-PATTERN FIREARMS**

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F41C 23/06	(2006.01)
F41A 3/54	(2006.01)

(52) **U.S. Cl.**

CPC ***F41A 3/62*** (2013.01); ***F41A 3/54*** (2013.01); ***F41C 23/06*** (2013.01)

(58) **Field of Classification Search**

CPC F41A 3/54; F41A 3/62; F41C 23/06
USPC 89/183
See application file for complete search history.

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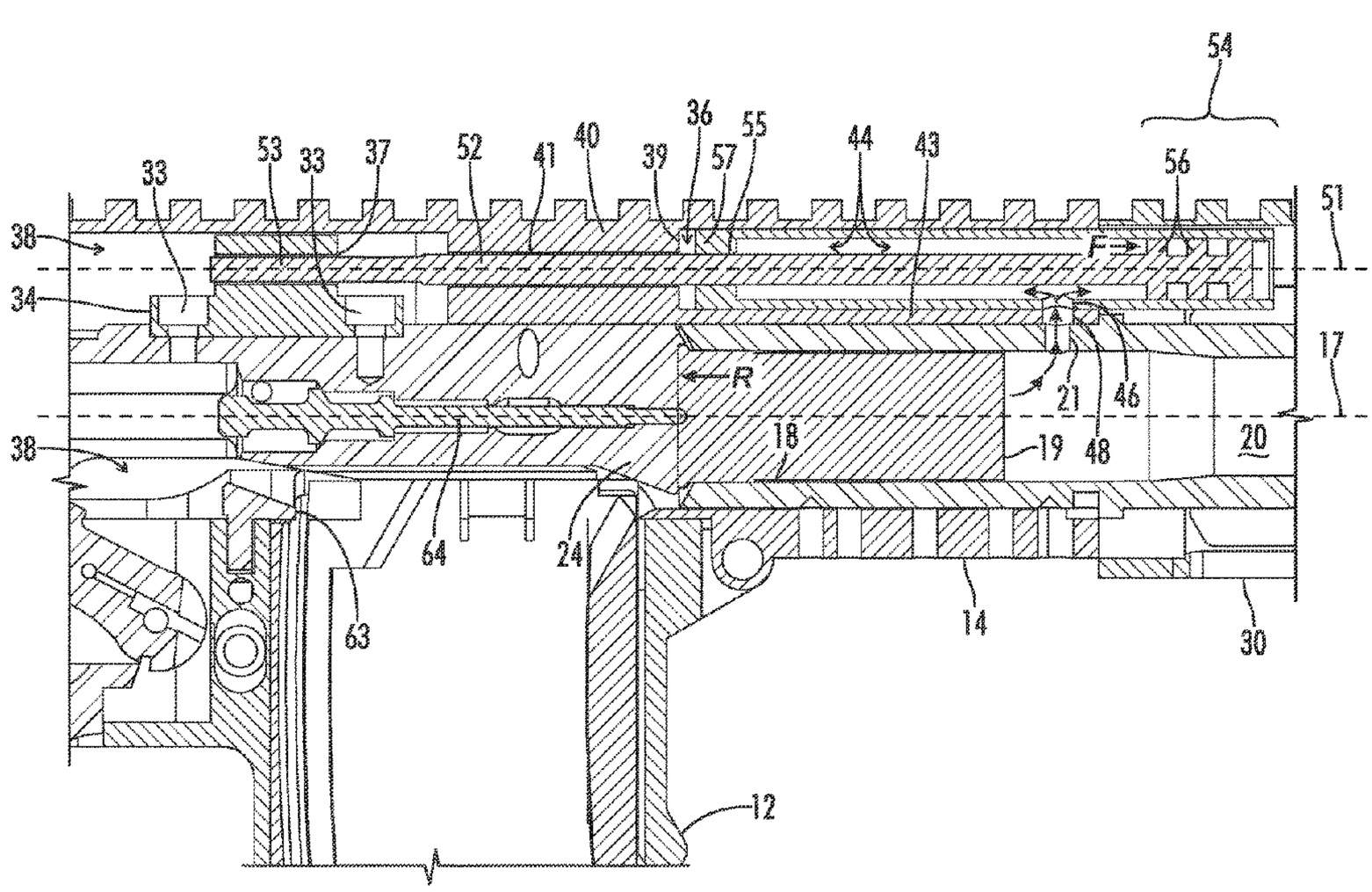
(57) **ABSTRACT**

A gas-delayed blowback firearm includes a lower receiver and an upper receiver releasably coupled thereto. A barrel having a cartridge chamber, an axial bore, and a barrel gas port is secured to the upper receiver. A bolt assembly in the upper receiver reciprocates between a forward in-battery position and a rearward position. A timing block is secured to the bolt assembly. A cylinder housing with an internal gas chamber and a cylinder gas port is secured to the upper receiver. A gas passageway fluidly communicates the barrel gas port with the cylinder gas port. A plunger in the gas chamber is secured to the timing block. The plunger reciprocates with the bolt assembly. Discharge of a cartridge received in the cartridge chamber temporarily pressurizes the gas chamber, applying a forward force to the plunger which causes the plunger to delay rearward travel of the bolt assembly.

19 Claims, 12 Drawing Sheets



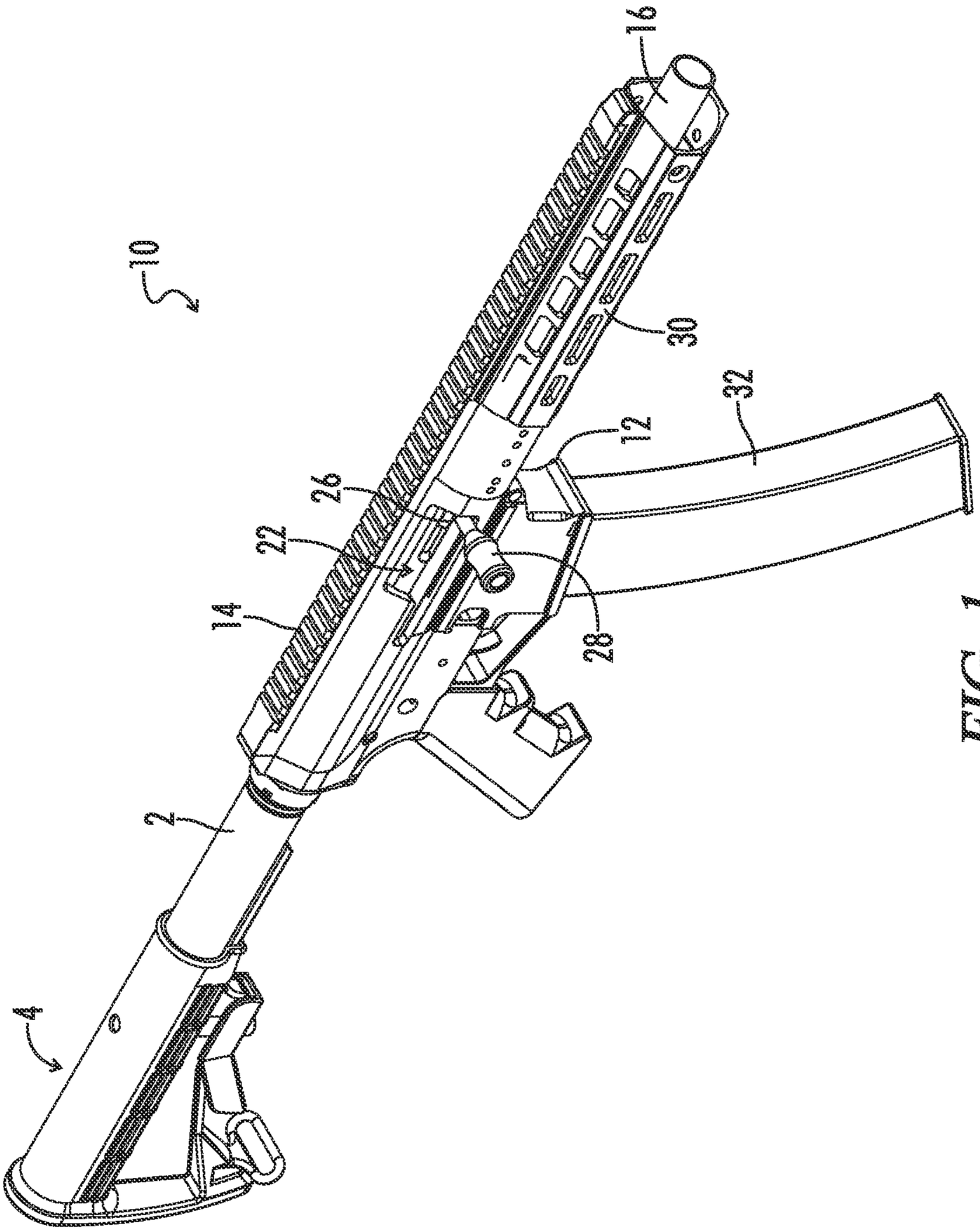


FIG. 1

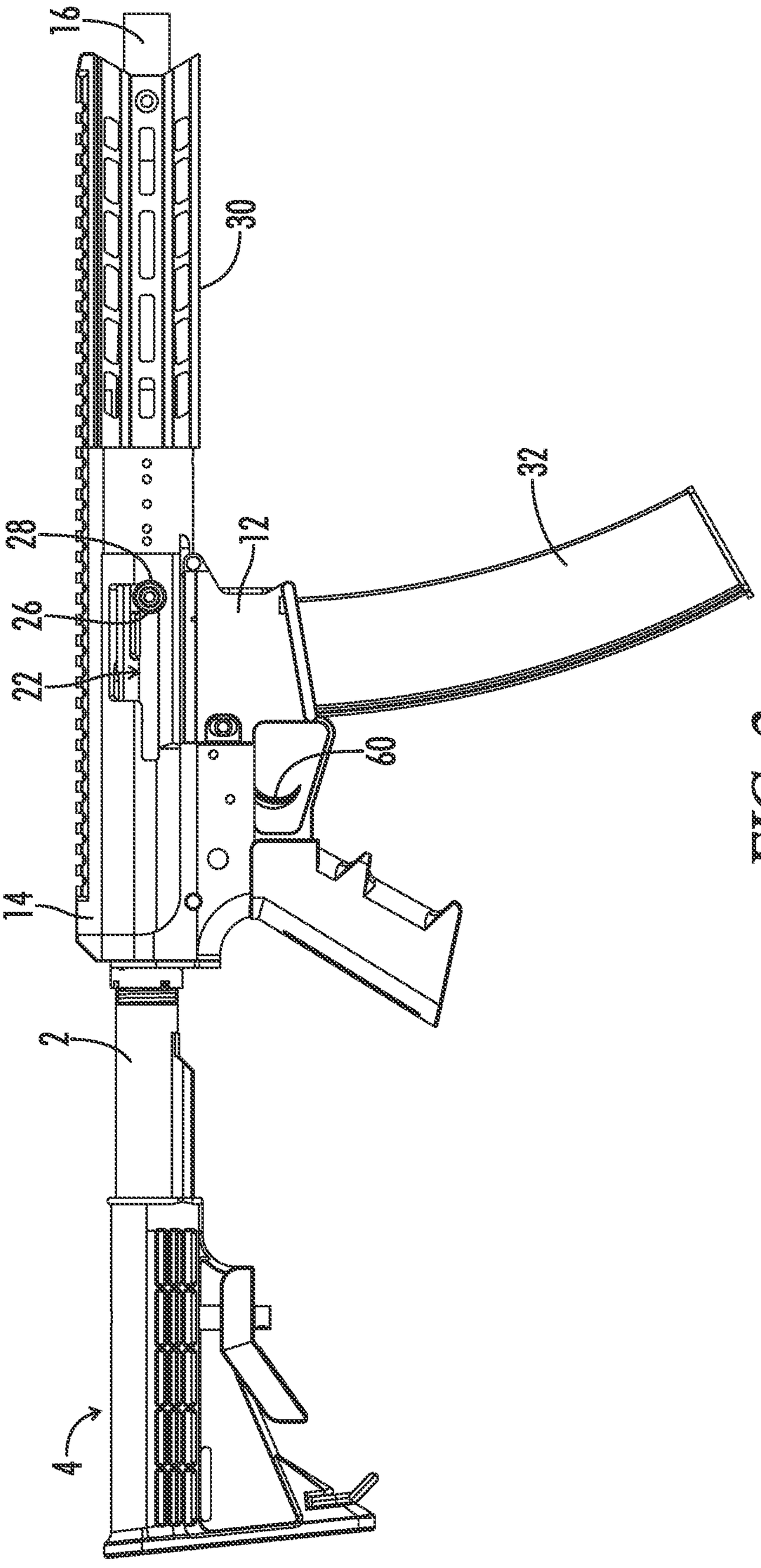


FIG. 2

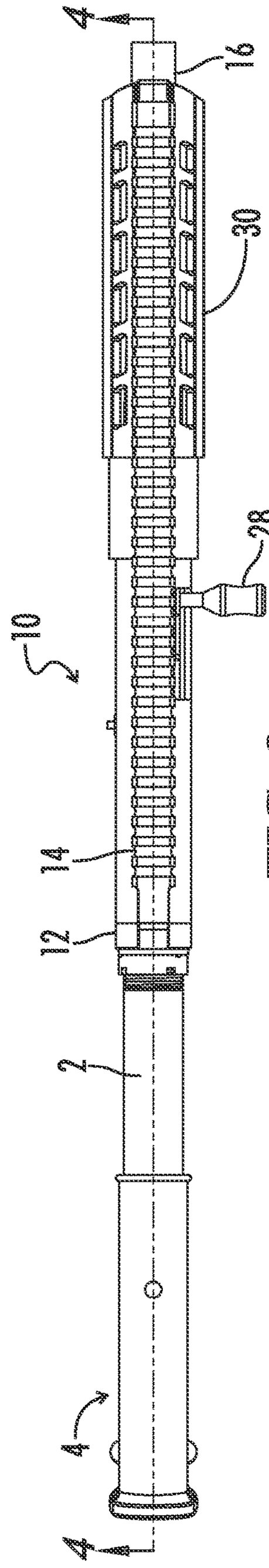


FIG. 3

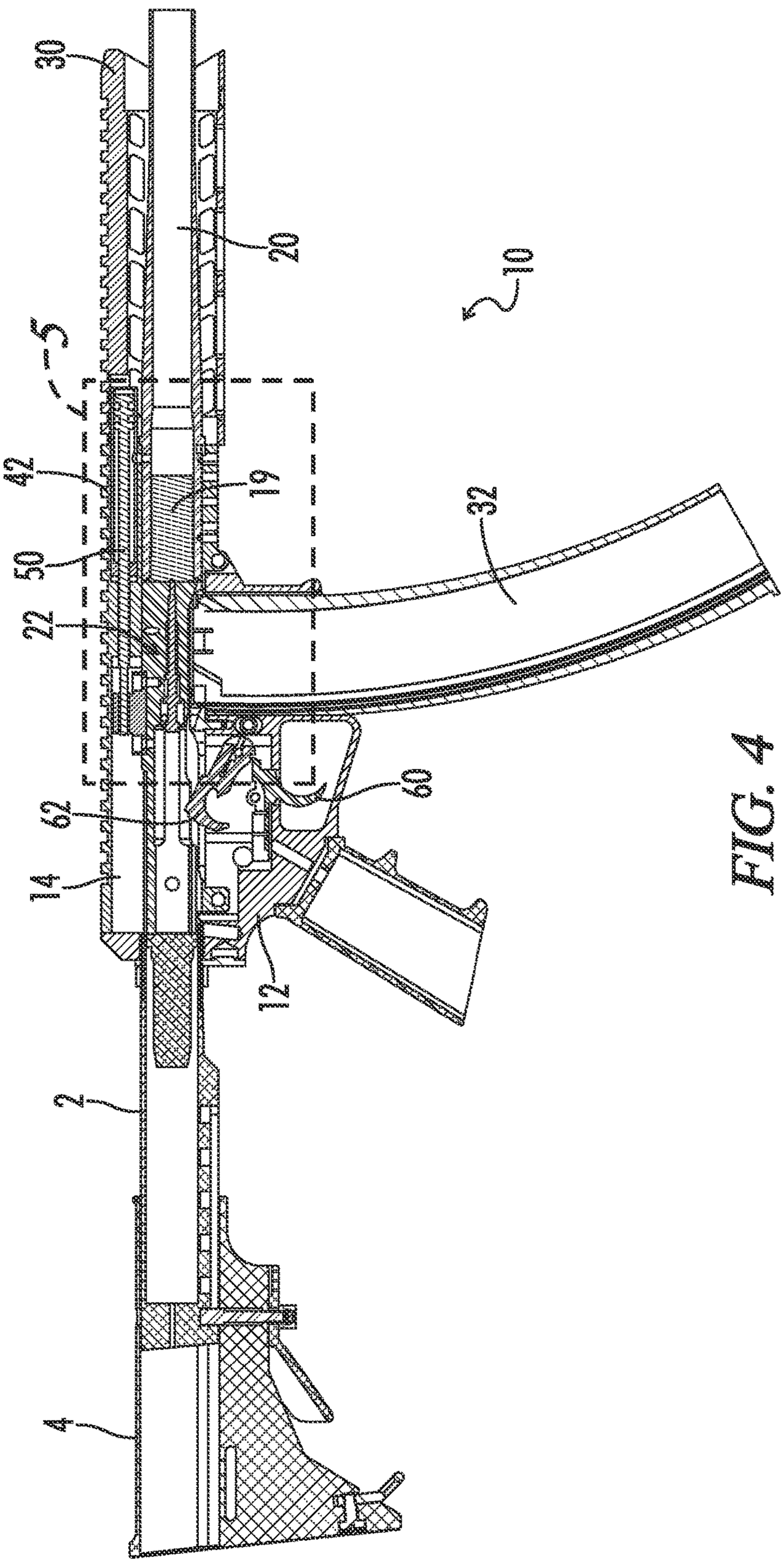


FIG. 4

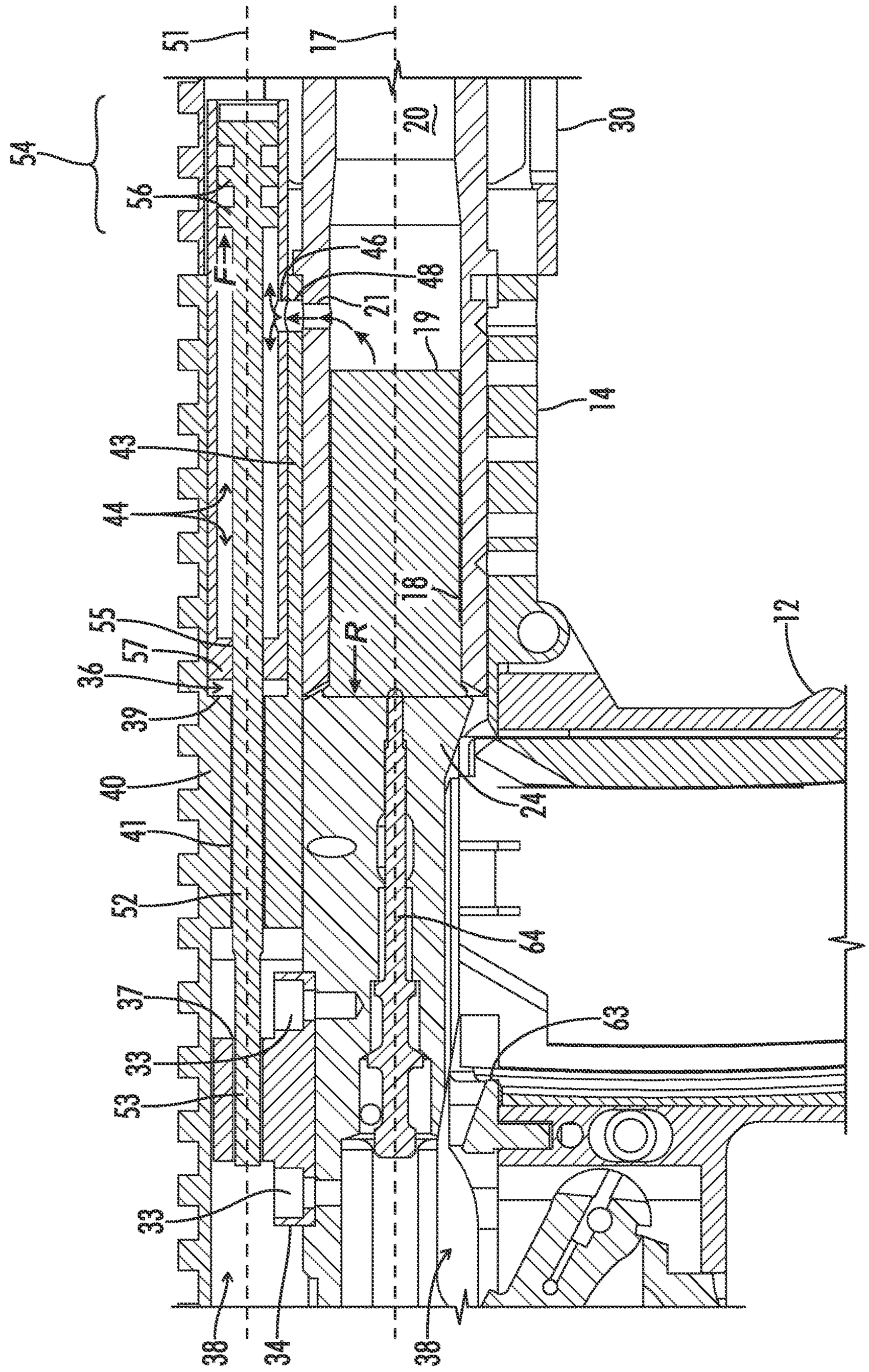

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FIG. 5

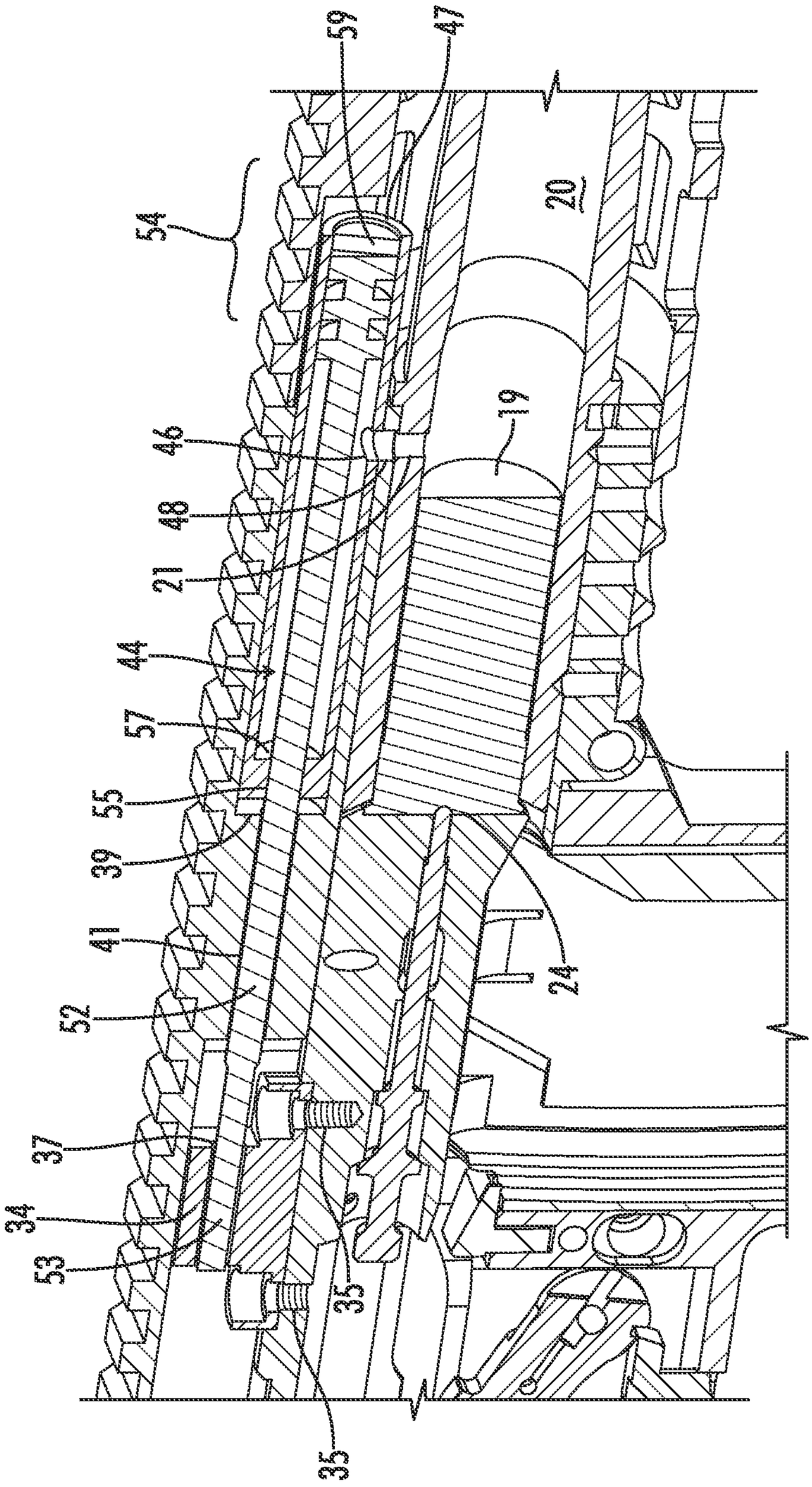

FIG. 6

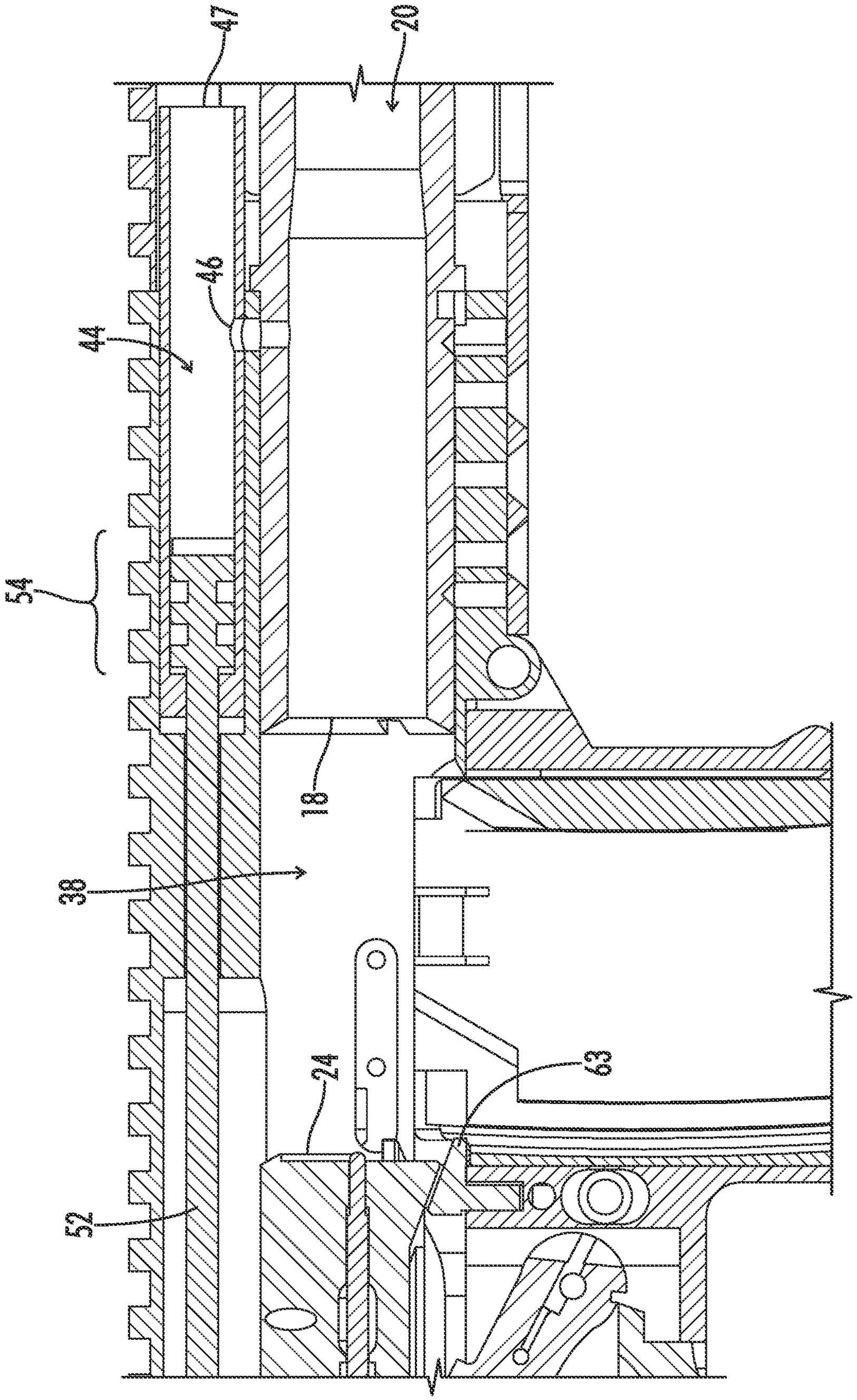

FIG. 7

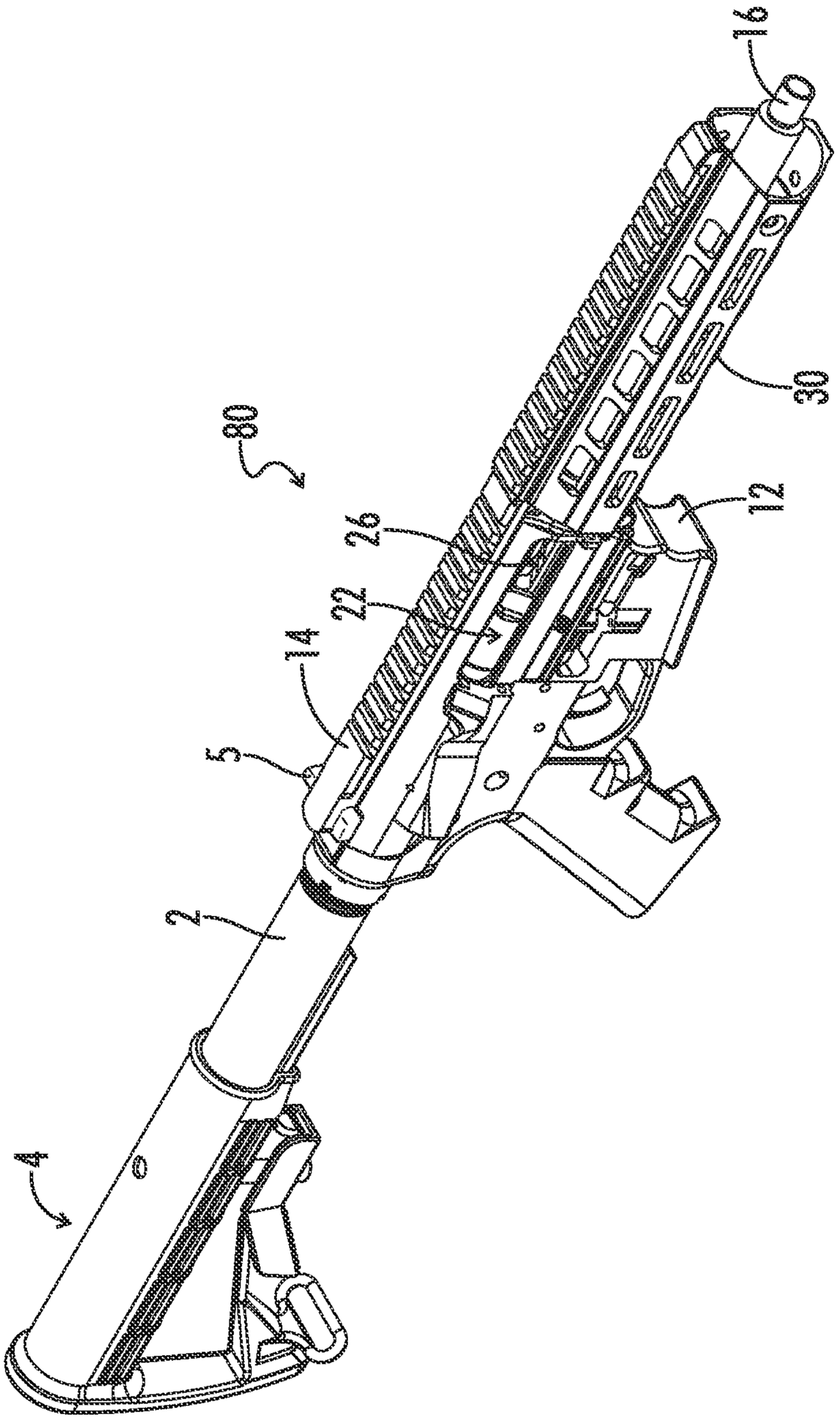

FIG. 8

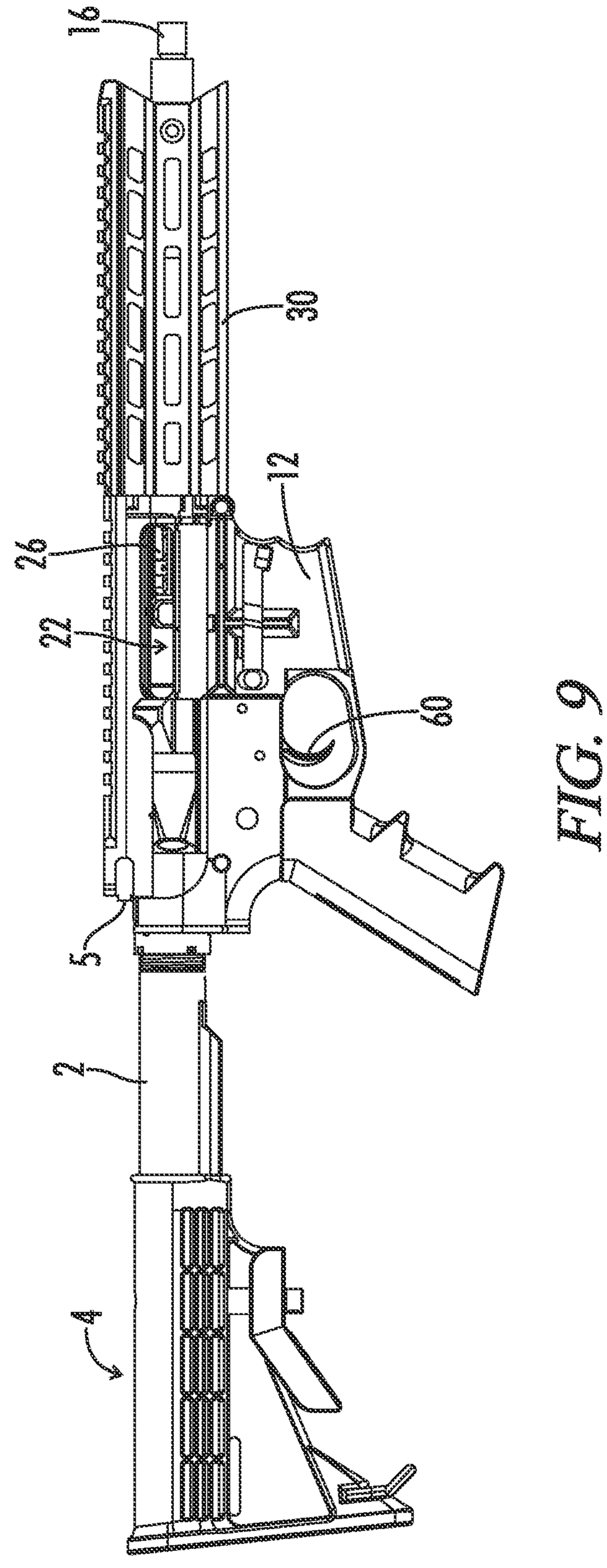

FIG. 9

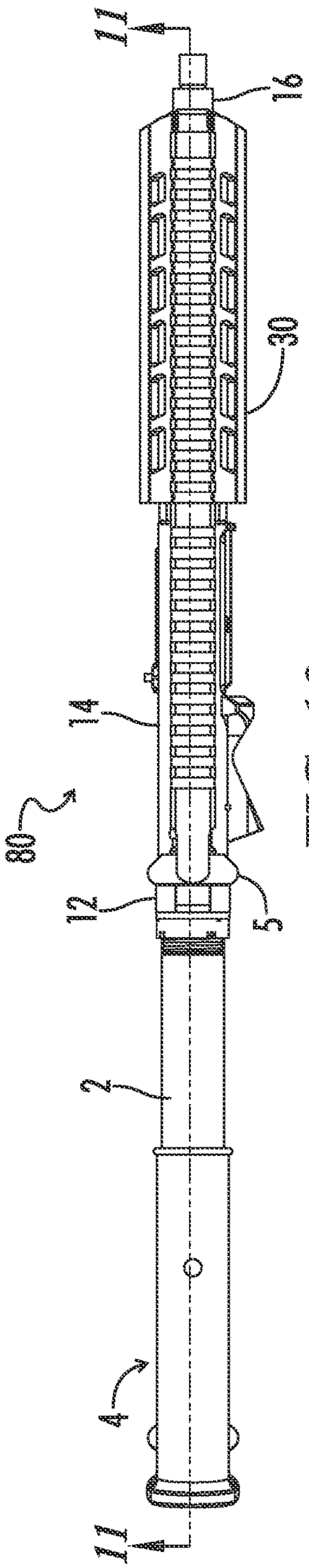

FIG. 10

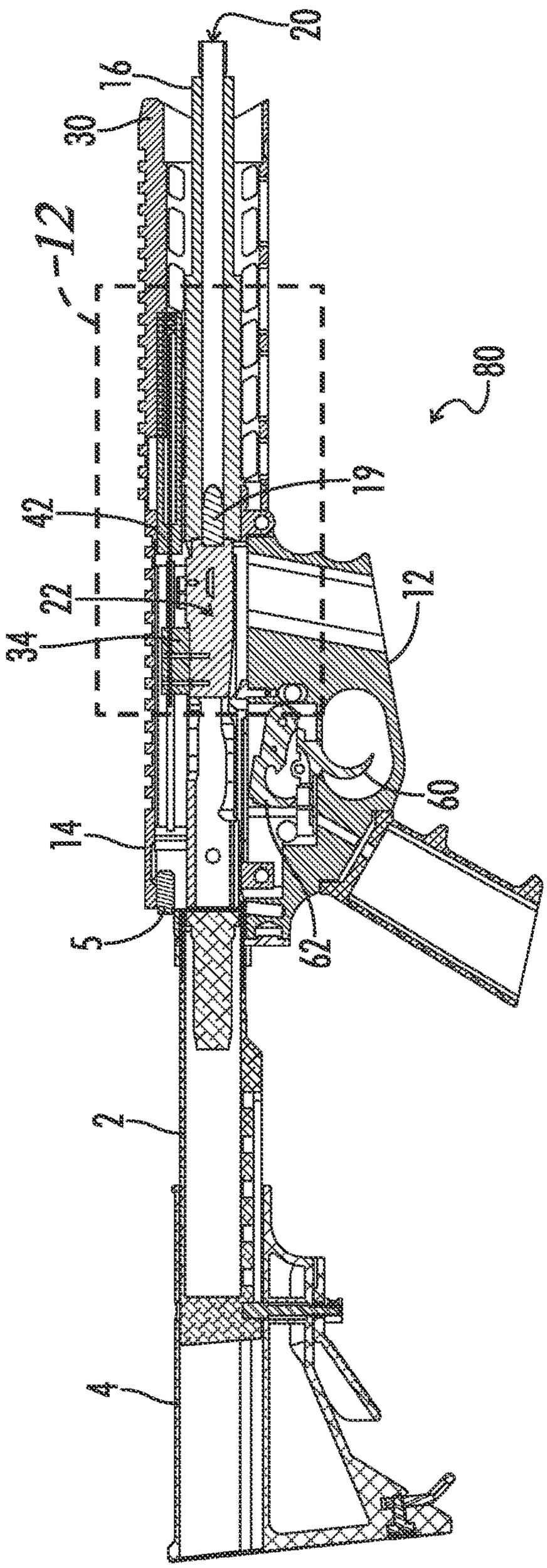

FIG. 11

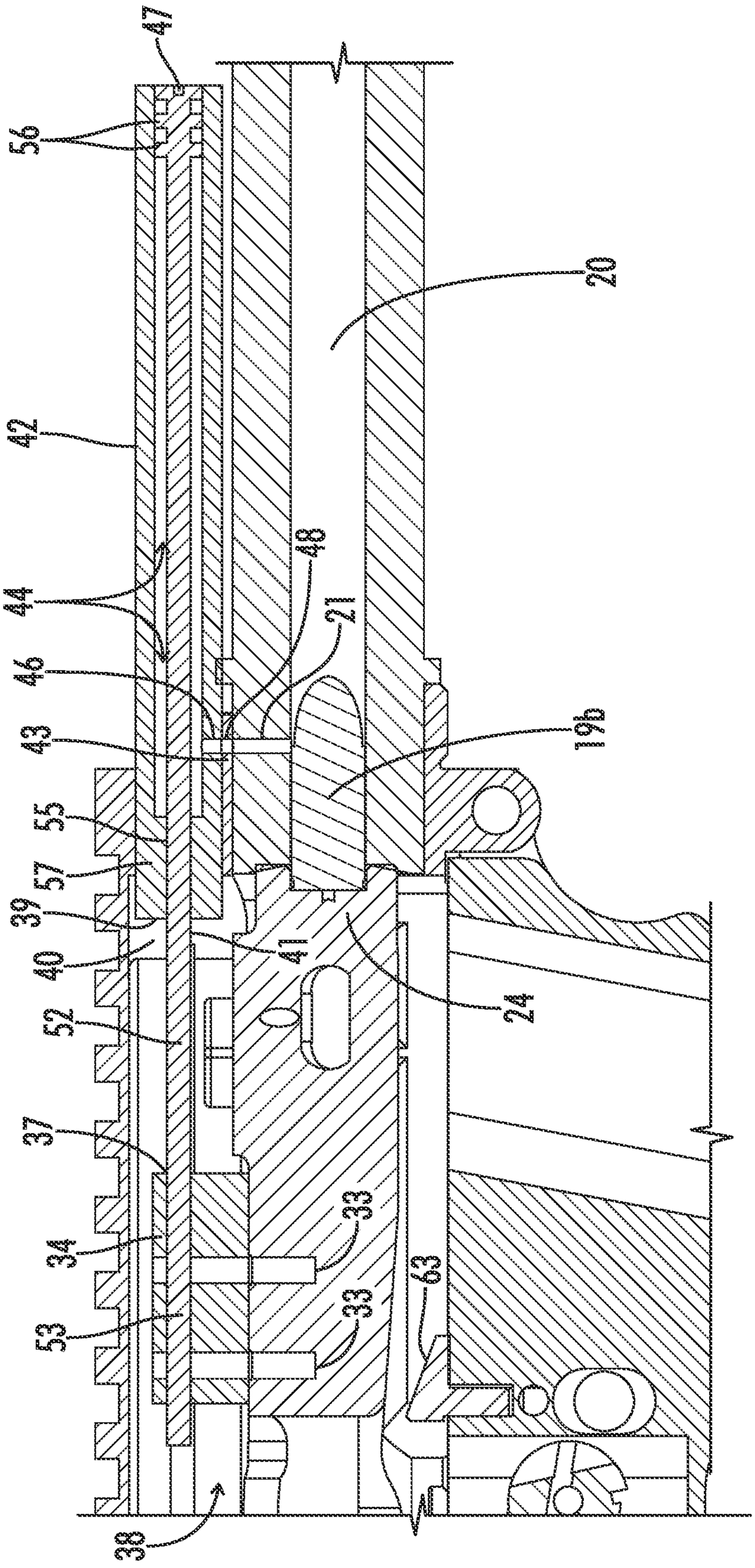

FIG. 12

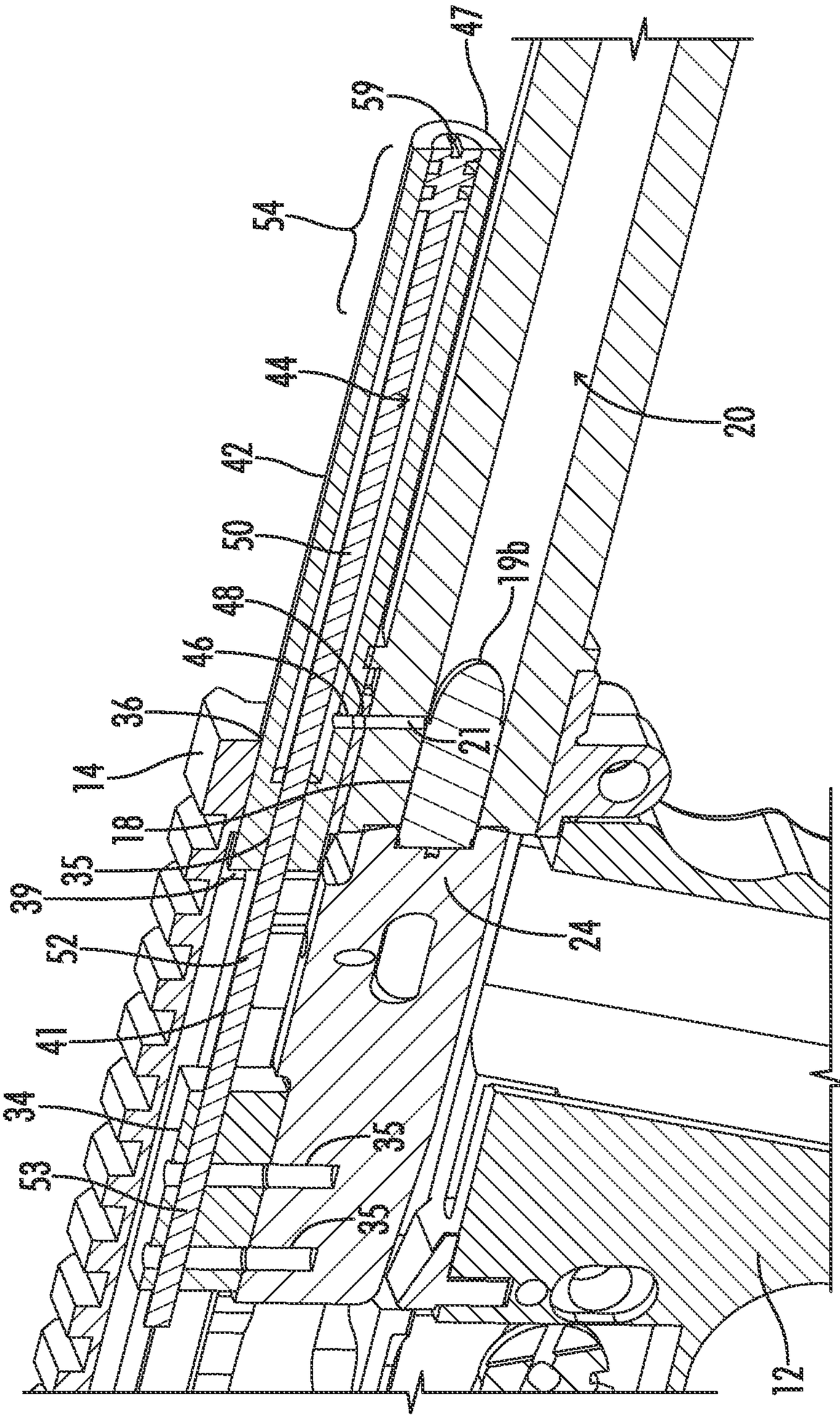
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FIG. 13

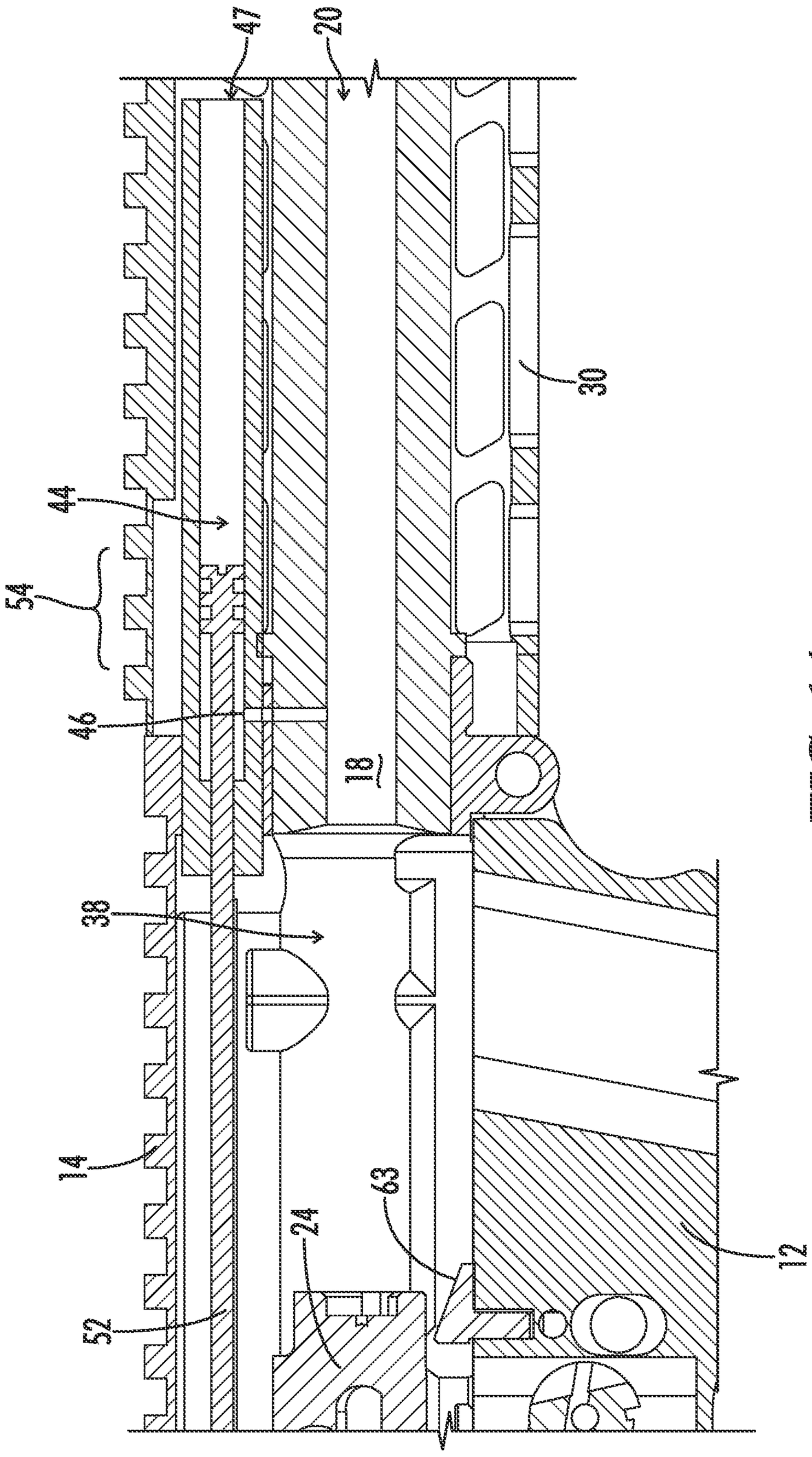

FIG. 14

GAS-DELAYED BLOWBACK OPERATING SYSTEM AND METHOD FOR AR-PATTERN FIREARMS

CROSS-REFERENCES TO RELATED APPLICATIONS

This non-provisional patent application claims priority to U.S. Provisional Patent Application Ser. No. 63/074,634, filed Sep. 4, 2020 and titled "GAS-DELAYED BLOWBACK OPERATING SYSTEM FOR AR-PATTERN FIREARMS," the entire disclosure of which is hereby incorporated by reference.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable.

REFERENCE TO SEQUENCE LISTING OR COMPUTER PROGRAM LISTING APPENDIX

Not Applicable.

BACKGROUND OF THE INVENTION

The present invention relates generally to operating systems for firearms. More specifically, the present invention relates to gas-delayed blowback operating systems for firearms.

Blowback is a well-known system of operation used in various self-loading firearms. Generally, blowback systems obtain energy to cycle the firearm from the motion of the cartridge case as it is pushed rearwardly by expanding gas created upon ignition of the propellant charge contained in the cartridge during discharge.

In simple blowback systems, the bolt assembly typically rests against the breech (i.e., the rear of the barrel) but is not locked in place. Upon ignition of the propellant, expanding gases push the projectile forward through the bore of the barrel while at the same time pushing the cartridge case rearward against the bolt. The cartridge case in turn pushes the bolt assembly rearward, which compresses the recoil spring and ejects the spent cartridge case. The recoil spring subsequently decompresses, driving the bolt assembly forward again, stripping the next cartridge from the magazine, and pushing the new cartridge into the chamber as the bolt assembly returns to its forward in-battery position.

Gas-delayed blowback systems differ from simple blowback systems in that gas-delayed systems vent propellant gases from the barrel into a cylinder with a piston that delays the opening of the bolt or slide in order to allow the projectile to exit the barrel before the cartridge case clears the chamber. This reduces operating pressures and requires fewer moving parts to cycle the firearm, which in turn results in appreciable savings in both weight and manufacturing costs, and makes the firearm more reliable and easier to service.

Nonetheless, gas-delayed blowback systems have only ever been successfully implemented in relatively low-pressure, small caliber handguns (i.e., pistols chambered in 9 mm or smaller calibers). This is because such handguns are typically simpler and lighter in design compared to most modern long guns and because higher-powered cartridges generate significantly higher pressures which require larger, heavier bolts to prevent the breech from opening prematurely upon discharge. Such relatively heavier bolt assemblies have historically proven too heavy to be reliably moved rearward solely by the expanding propellant gasses pushing the cartridge case into the bolt face. This failure to consistently move the bolt assembly rearward results in unreliable cycling of the action, and thus an unreliable and potentially unsafe firearm. Consequently, gas-delayed blowback systems are not found in modern long guns.

The WALTHER® CCP semi-automatic pistol is one of the very few modern firearms in production today which employs a gas-delayed blowback system. This pistol uses a fixed barrel and a gas chamber built into the frame below the barrel. A piston is secured at its forward end to the forward end of the slide. When a cartridge is discharged, expanding gas enters the cylinder below the barrel and delays the rearward motion of the piston, and thus the slide to which the piston is secured, so that the projectile can exit the barrel before the cartridge case can exit the chamber. However, this system is clearly unsuitable for and would not function with firearms which lack a reciprocating slide.

AR-pattern (i.e., AR-style) firearms, including the AR-15® and AR-100, the construction and operation of which are well-known, are the most popular and widely owned firearms currently in use in the United States. These firearms are famous for their reliability, modularity, and ease of use, and have been chambered to function with a wide variety of ammunition, ranging from .17 to .500 caliber cartridges, as well as 12 gauge, 20 gauge, and .410 bore shotshell cartridges. AR-pattern firearms do not include a reciprocating slide and typically employ either a direct impingement or gas piston operating system (both of which are well-known) to cycle the bolt assembly. Both operating systems use a rotating bolt that locks into a barrel extension behind the cartridge case head when a cartridge is chambered. The bolt head includes a plurality of radially extending locking lugs that are complimentary in number to a plurality of protrusions formed in the barrel extension. Once the bolt has pushed a cartridge into the chamber, the bolt rotates to cause the locking lugs to engage the protrusions on the barrel extension and thus firmly lock the bolt in place behind the case head. This enables the bolt to withstand the pressure generated upon discharge of the cartridge and prevent propellant gases from being expelled out of the receiver toward the shooter. When the cartridge is fired, the bolt rotates in the opposite direction and retracts to extract and eject the spent casing before chambering a new round. No AR-pattern firearm with a gas-delayed blowback system is known to have ever been developed.

Accordingly, what is needed are improvements in firearms and operating systems for firearms.

BRIEF SUMMARY

This Brief Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter. Features of the presently disclosed invention overcome or minimize some or all of the identified deficiencies of the

prior art, as will become evident to those of ordinary skill in the art after a study of the information presented in this document.

It is an object of the present invention to provide a gas-delayed operating system for AR-pattern firearms, as well as a gas-delayed blowback AR-pattern firearm, which eliminates the need of traditional AR-pattern firearms for a rotating bolt with locking lugs, requires fewer parts to cycle the firearm, and simplifies firearm operation and maintenance while simultaneously preventing premature extraction of the cartridge until gas pressure in the system has dropped to safe levels.

One aspect of the present invention provides a gas-delayed blowback firearm, comprising a lower receiver; an upper receiver releasably coupled to the lower receiver; a barrel secured to the upper receiver, the barrel having a cartridge chamber, an axial bore, and a barrel gas port in fluid communication with the bore; a bolt assembly configured to reciprocate in the upper receiver between a forward in-battery position and a rearward position; a timing block on the bolt assembly; a cylinder housing secured to the upper receiver, the cylinder housing having an internal gas chamber and a cylinder gas port in fluid communication with the gas chamber; a gas passageway fluidly communicating the barrel gas port with the cylinder gas port; and a plunger in the gas chamber secured to the timing block such that the plunger reciprocates with the bolt assembly; wherein discharge of a cartridge received in the cartridge chamber temporarily pressurizes the gas chamber, applying a forward force to the plunger which causes the plunger to delay rearward travel of the bolt assembly.

In another aspect, the invention provides a gas-delayed blowback firearm, comprising an AR-pattern lower receiver; an upper receiver releasably couplable to the lower receiver; a barrel attachable to the upper receiver, the barrel having a cartridge chamber, an axial bore, and a barrel gas port in fluid communication with the bore; a bolt assembly receivable in the upper receiver and configured to reciprocate therein between a forward in-battery position and a rearward position; a timing block attachable to the bolt assembly; a cylinder housing attachable to the upper receiver, the cylinder housing having an internal gas chamber and a cylinder gas port in fluid communication with the gas chamber a recess defined in a forward portion of the upper receiver, the recess configured to receive at least a portion of the cylinder housing when the cylinder housing is attached to the upper receiver; a gas passageway defined through the upper receiver which fluidly communicates the barrel gas port with the cylinder gas port when the barrel and the cylinder housing are attached to the upper receiver; and a plunger receivable in the gas chamber and attachable to the timing block such that the plunger reciprocates with the bolt assembly when the plunger is attached to the timing block and the timing block is attached to the bolt assembly; wherein discharge of a cartridge received in the cartridge chamber temporarily pressurizes the gas chamber, applying a forward force to the plunger which causes the plunger to delay rearward travel of the bolt assembly until the pressure in the gas chamber decreases enough for a rearward force applied by the cartridge against the bolt assembly to overcome the forward force applied to the plunger and move the bolt assembly toward the rearward position.

In yet another aspect, the invention provides an upper receiver assembly for a gas-delayed blowback firearm, comprising an upper receiver releasably couplable to an AR-pattern lower receiver; a barrel attachable to the upper receiver, the barrel having a cartridge chamber, an axial bore, and a barrel gas port in fluid communication with the bore; a bolt assembly receivable in the upper receiver and configured to reciprocate therein between a forward in-battery position and a rearward position; a timing block attachable to the bolt assembly; a cylinder housing attachable to the upper receiver, the cylinder housing having an internal gas chamber and a cylinder gas port in fluid communication with the gas chamber; a recess defined in a forward portion of the upper receiver, the recess configured to receive at least a portion of the cylinder housing when the cylinder housing is attached to the upper receiver; a gas passageway defined through the upper receiver which fluidly communicates the barrel gas port with the cylinder gas port when the barrel and the cylinder housing are attached to the upper receiver; and a plunger receivable in the gas chamber and attachable to the timing block such that the plunger reciprocates with the bolt assembly when the plunger is attached to the timing block and the timing block is attached to the bolt assembly; wherein discharge of a cartridge received in the cartridge chamber temporarily pressurizes the gas chamber, applying a forward force to the plunger which causes the plunger to delay rearward travel of the bolt assembly until the pressure in the gas chamber decreases such that a rearward force applied by the cartridge against the bolt assembly overcomes the forward force applied to the plunger and moves the bolt assembly toward the rearward position.

Numerous other objects, advantages and features of the present disclosure will be readily apparent to those of skill in the art upon a review of the following drawings and description of a preferred embodiment.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Non-limiting and non-exhaustive embodiments are described with reference to the following figures, wherein like reference numerals refer to like parts throughout the various drawings unless otherwise specified. In the drawings, not all reference numbers are included in each drawing, for the sake of clarity.

FIG. **1** is an elevated front perspective view of an embodiment of an AR-pattern firearm having a gas-delayed blowback operating system of the present invention showing the firearm in an in-battery configuration.

FIG. **2** is a right-side elevational view of the firearm of FIG. **1**.

FIG. **3** is a top plan view of the firearm of FIG. **1**.

FIG. **4** is a sectional view of the firearm of FIG. **1** taken along line **4**-**4** of FIG. **3**.

FIG. **5** is a magnified view of the firearm of FIG. **1** at location **5** of FIG. **4**.

FIG. **6** is a magnified perspective view of the firearm of FIG. **1** at location **5** of FIG. **4**.

FIG. **7** is a magnified view of the firearm of FIG. **1** at location **5** of FIG. **4** showing the firearm in an out-of-battery configuration with the bolt assembly fully retracted in the rearward position.

FIG. **8** is an elevated front perspective view of another embodiment of an AR-pattern firearm having a gas-delayed blowback operating system of the present invention showing the firearm in an in-battery configuration. The magazine is omitted for clarity.

FIG. **9** is a right-side elevational view of the firearm of FIG. **8**.

FIG. **10** is a top plan view of the firearm of FIG. **8**.

FIG. **11** is a sectional view of the firearm of FIG. **8** taken along line **11-11** of FIG. **10**.

FIG. **12** is a magnified view of the firearm of FIG. **8** at location **12** of FIG. **11**, showing the firearm with the handguard omitted for clarity.

FIG. **13** is a magnified perspective view of the firearm of FIG. **8** at location **12** of FIG. **11**, showing the firearm with the handguard omitted for clarity.

FIG. **14** is a magnified view of the firearm of FIG. **8** at location **12** of FIG. **11** showing the firearm in an out-of-battery configuration with the bolt assembly fully retracted in the rearward position.

DETAILED DESCRIPTION

While the making and using of various embodiments of the present invention are discussed in detail below, it should be appreciated that the present invention provides many applicable inventive concepts that are embodied in a wide variety of specific contexts. The specific embodiments discussed herein are merely illustrative of specific ways to make and use the invention and do not delimit the scope of the invention.

To facilitate the understanding of the embodiments described herein, a number of terms are defined below. The terms defined herein have meanings as commonly understood by a person of ordinary skill in the portions relevant to the present invention. Terms such as "a," "an," and "the" are not intended to refer to only a singular entity, but rather include the general class of which a specific example may be used for illustration. The terminology herein is used to describe specific embodiments of the invention, but their usage does not delimit the invention, except as set forth in the claims.

As described herein, an "upright" position is considered to be the position of apparatus components while in proper operation or in a natural resting position as described and shown herein, for example, in FIG. **2**. "Vertical," "horizontal," "above," "below," "side," "top," "bottom," "upper," "lower," and other orientation terms are described with respect to this upright position during operation, unless otherwise specified, and are used to provide an orientation of embodiments of the invention to allow for proper description of example embodiments. A person of skill in the art will recognize, however, that the apparatus can assume different orientations when in use. The term "when" is used to specify orientation for relative positions of components, not as a temporal limitation of the claims or apparatus described and claimed herein unless otherwise specified. The terms "above", "below", "over", and "under" mean "having an elevation or vertical height greater or lesser than" and are not intended to imply that one object or component is directly over or under another object or component.

The phrase "in one embodiment," as used herein does not necessarily refer to the same embodiment, although it may. Conditional language used herein, such as, among others, "can," "might," "may," "e.g.," and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or states. Thus, such conditional language is not generally intended to imply that features, elements and/or states are in any way required for one or more embodiments.

As used herein, the term "forward" refers to a direction extending along a longitudinal axis of the disclosed firearm toward a muzzle of the firearm. Conversely, the term "rearward" refers to a direction extending along the longitudinal axis of the firearm away from the muzzle toward a buttstock or end of the firearm opposite the muzzle. A "rearward" direction is thus the opposite of a "forward" direction.

All measurements should be understood as being modified by the term "about" regardless of whether the word "about" precedes a given measurement.

All combinations of method or process steps as used herein can be performed in any order, unless otherwise specified or clearly implied to the contrary by the context in which the referenced combination is made.

The methods and devices disclosed herein, including components thereof, can comprise, consist of, or consist essentially of the essential elements and limitations of the embodiments described herein, as well as any additional or optional components or limitations described herein or otherwise useful.

FIGS. **1-7** depict an embodiment of an AR-pattern firearm having a gas-delayed blowback operating system **10**. A gas-delayed blowback firearm **10** includes an AR-pattern lower receiver **12** and an upper receiver **14** releasably coupled to the lower receiver **12**. A receiver extension **2** is secured to the rear end of the lower receiver **12**. A buttstock assembly **4** is secured to the receiver extension **2**. A barrel **16** is secured to the forward portion of the upper receiver **14**. The barrel **16** includes a cartridge chamber **18**, an axial bore **20**, and a barrel gas port **21**. The cartridge chamber **18** is a short region of smooth bore sized to receive a cartridge **19**, which can be a 12-gauge shotshell as shown in FIGS. **1-7**, or another relatively low-pressure cartridge, including but not limited to, 9 mm, .38 caliber, .45 caliber, .40 caliber, and all shotshell gauges. The barrel gas port **21** is a hole defined through an upper portion of the barrel **16** slightly forward of and proximate to the chamber **18**. The barrel gas port **21** is in fluid communication with the bore **20**.

A bolt assembly **22** is received in a bolt cavity **38** of the upper receiver **14**. The bolt assembly **22** reciprocates forward and rearward in the bolt cavity **38** along a longitudinal axis **17** of the upper receiver **14** to load cartridges **19** into the chamber **18** of the barrel **16** and eject spent cartridge casings after discharge. As such, the bolt assembly **22** reciprocates between a forward in-battery position (shown in FIG. **5**) and a rearward position (shown in FIG. **7**). The bolt assembly **22** includes a bolt **24**, an extractor **26**, a bolt knob **28**, and a firing pin **64**. A handguard **30** is secured to the forward end of the upper receiver **14** around the barrel **16** to protect the hand of a user from heat evolved from the barrel **16** upon firing of the gas-delayed blowback firearm **10**. A magazine **32** received in the lower receiver **12** supplies cartridges (omitted for clarity) for loading by the bolt assembly **22** into the chamber **18**.

A timing block **34** is secured to an upper portion of the bolt **24**. In some embodiments, the timing block **34** can be secured to the bolt **24** using one or more threaded fasteners **33**, such as screws, which are receivable through the timing block **34** in corresponding threaded recesses **35** formed in the upper portion of the bolt **24**. In some embodiments, the timing block **34** can be secured to the bolt assembly **22** using alternative securing means, including but not limited to welds and pins, each alone or together with one or more threaded fasteners **33**. Since a rearward force applied by the cartridge **19** against the bolt assembly **22** upon or shortly after discharge of a cartridge **19** received in the cartridge chamber **18** is what moves the bolt assembly **22** out of the forward in-battery position (see FIG. **5**) and into the rearward position (see FIG. **7**), the mass of the timing block **34**

can be selected to affect the speed and timing of rearward travel of the bolt assembly **22** upon or shortly after discharge of cartridge **19**.

A recess **36** is formed in a forward portion of the upper receiver **14** directly above the barrel **16**. A forward surface **39** of a rear wall **40** defines the rear end **39** of the recess **36**. The rear wall **40** partitions or separates the recess **36** from the bolt cavity **38**. A portion of the bolt cavity **38** in which the timing block **34** reciprocates is disposed longitudinally rearward from the recess **36**. The bolt assembly **22** and attached timing block **34** reciprocate back and forth in the bolt cavity **38** between the forward in-battery position (see FIG. **5**) and the rearward position (see FIG. **7**) during cycling of the firearm **10**. An elongated passageway **41** extends through the rear wall **40** and operatively connects the recess **36** to the bolt cavity **38**. A thin wall **43** defines a bottom surface of the recess **36** and separates the recess **36** from the barrel **16**.

An elongated cylinder housing **42** is secured within the recess **36** of the upper receiver **14**. The recess **36** is shaped and sized to receive and securely engage a portion of the cylinder housing **42**. The cylinder housing **42** and the recess **36** can include complimentary screw threads such that the cylinder housing **42** is threadingly engaged with the recess **36** when the cylinder housing **42** is received in the recess **36**. In some embodiments, the cylinder housing **42** can be secured in the recess **36** using one or more pins (not shown) extending through a portion of each of the upper receiver **14** and the cylinder housing **42**. For increased securement, the cylinder housing **42** can be secured in the recess **36** using complimentary screw threads on the housing **42** and the recess **36**, and one or more pins (not shown).

The cylinder housing **42** includes an internal gas chamber **44**, a cylinder gas port **46** defined in the bottom of the cylinder housing **42**, an open forward end **47**, and a rear end **57** through which is defined a hole **55**. The cylinder gas port **46** in fluid communication with the gas chamber **44**. The gas chamber **44** extends axially through the cylinder housing **42** substantially parallel to the bore **20** of the barrel **16** when the barrel **16** is properly secured to the upper receiver **14** and the cylinder housing **42** is properly secured in the recess **36** of the receiver **14**. When properly secured in the recess **36** as exemplified in FIGS. **5-7**, the cylinder housing **42** is oriented such that the cylinder gas port **46** is directly above and coaxially aligned with the barrel gas port **21**. In some embodiments, the cylinder gas port **46** can be substantially vertically aligned with the barrel gas port **21**.

A gas passageway **48** extends through the thin wall **43** portion of the upper receiver **14** between the barrel gas port **21** and the cylinder gas port **46**. The gas passageway **48** operatively links and fluidly communicates the barrel gas port **21** with the cylinder gas port **46** so that the bore **20** of the barrel **16** is in fluid communication with the gas chamber **44** through the gas passageway **48**. When the barrel **16** is properly secured to the upper receiver **14** and the cylinder housing **42** is properly secured in the recess **36** of the receiver **14** as exemplified in FIGS. **5-7**, the cylinder gas port **46**, the gas passageway **48**, and the barrel gas port **21** are all coaxially aligned. In some embodiments, each of the cylinder gas port **46**, the gas passageway **48**, and the barrel gas port **21** can be substantially vertically aligned. The phrase "substantially vertically aligned" as used herein means that the indicated ports **21**, **46** and gas passageway **48** are sufficiently aligned in a vertical dimension that gas from the barrel bore **20** can flow through the indicated ports **21**, **46** and gas passageway **48** into the gas chamber **44**. It should be noted that, while the gas passageway **48** is depicted in the drawings as a hole defined through the thin wall **43** portion of the upper receiver **14**, the gas passageway **48** in some embodiments can be a tube extending between gas ports **21**, **46** regardless of whether an intervening portion of the upper receiver **14** exists between the ports.

A plunger **50** is received within the gas chamber **44** of the cylinder housing **42** through the open forward end **47**. The plunger **50** includes an elongated rod portion **52** and a head portion **54**. The rod portion **52** has a rod diameter D_R, while the head portion **54** has a head diameter D_H. The head diameter D_H is greater than the rod diameter D_R. The head diameter D_H can be equal to or slightly less than a diameter of the gas chamber **44**. The head diameter D_H is selected so the interior surface of the gas chamber **44** forms a tight seal around the plunger head **54**. The rod portion **52** extends rearwardly out of the hole **55** in the rear end **57** of the cylinder housing **42** and through the elongated passageway **41** in the partition **40** into the bolt cavity **38**. The rear end **53** of the rod portion **52** is received and secured in an aperture **37** formed in the timing block **34**. In this way, the plunger **50** is secured to the bolt assembly **22**. As such, the plunger **50** is configured to reciprocate backward and forward within the gas chamber **44** along an axis **51** of the cylinder housing **42** with the bolt assembly **22** when the bolt assembly **22** reciprocates backward and forward between the forward in-battery position (see FIG. **5**) and the rearward position (see FIG. **7**) during discharge and cycling of the firearm **10**. In some embodiments, the rear end **53** of the rod **52** and the aperture **37** in the timing block **34** can include complimentary screw threads such that the rod **52** is threadingly engaged with the aperture **35** and thus the timing block **34**. For increased securement, in some embodiments, the rod **52** can also be pinned or otherwise secured to timing block **34**.

The head portion **54** of the plunger **50** rests in the gas chamber **44** forward of the cylinder gas port **46** when the plunger **50** and attached bolt assembly **22** are in the forward in-battery position, as best shown in FIGS. **5-6**. The plunger head **54** includes a plurality of radially extending spaced fins or baffles **56**. The baffles **56** work like a piston to capture pressurized gasses from the barrel bore **20** generated upon discharge of a cartridge **19**. The forward face of the plunger head **54** includes a notch **59**. The notch **59** can be shaped and sized to receive a tool, such as a flat head screwdriver. This facilitates securement of the plunger **50** within the cylinder housing **42** by enabling a user to more easily rotate or thread the rod portion **52** into the aperture **37** of the timing block **34**.

In use, a gas-delayed blowback AR-pattern firearm **10** of the present invention is advantageously operated in a manner that will be apparent to those of ordinary skill in the art familiar with AR-pattern firearms. Specifically, depressing the trigger **60** when a cartridge **19** is chambered and the firearm is charged (e.g., with the bolt assembly **22** in the forward in-battery position) causes the hammer **62** to strike the firing pin **64**. The bolt catch **63** is forward of the hammer **62**. The hammer **62** moves the firing pin **64** forward to strike a primer (not shown) located on the back of a cartridge **19** received in the chamber **18**, which ignites the propellant charge contained in the cartridge **19**. Ignition of the propellant in the cartridge **19** generates expanding (i.e., pressurized) gasses in the bore **20** and causes the cartridge casing (i.e., hull) to apply a rearward force against the face of the bolt **24**. This simultaneously propels one or more projectiles contained in the cartridge **19** down the bore **20** of the barrel **16** and out the muzzle of the firearm **10** toward a target.

At least some of the pressurized gasses generated upon discharge of the cartridge **19** immediately pass from the bore

20 of the barrel 16 through the barrel gas port 21, the gas port passageway 48, the cylinder gas port 46, and into the gas chamber 44, as indicated by arrows in FIG. 5. This temporarily pressurizes the portion of the gas chamber 44 between the rear end 57 of the cylinder housing 42 and the baffles 56 on the plunger head 54. Pressurization of the gas chamber 44 when the plunger 50 is in the forward in-battery position applies a forward force to the plunger head 54. The forward force on the plunger head 54 is initially greater than the rearward force applied by the cartridge 19 against the bolt assembly 22 upon discharge. As such, the forward force causes the plunger 50 to delay rearward travel (i.e., rearward reciprocation) of the bolt assembly 22 because the rear end 53 of the plunger rod 52 is secured to the timing block 34 and the timing block 34 is secured to the bolt assembly 22. Thus, the forward force applied to the plunger head 54 holds the plunger rod 52 and the connected timing block 34 and bolt assembly 33 in the forward in-battery position for a brief predetermined period of time.

The plunger 50 delays rearward travel of the bolt assembly 22 until the pressure in the gas chamber 44 decreases to a predetermined level whereby the rearward force applied by the cartridge 19 against the bolt assembly 22 overcomes the forward force applied to the plunger head 54 and moves the bolt assembly 22 toward the rearward position shown in FIG. 7. In some embodiments, the plunger 50 delays rearward travel of the bolt assembly 22 until the pressure in the gas chamber 44 decreases enough for the rearward force applied by the cartridge 19 against the bolt assembly 22 to overcome the forward force applied to the plunger head 54 and move the bolt assembly 22 toward the rearward position. In this way, the forward force applied to the plunger head 54 by the pressurized gasses maintains the bolt assembly 22 the forward in-battery position until the gas pressure drops sufficiently for extraction of the cartridge casing to be safe.

As noted above, rearward travel of the bolt assembly 22 is delayed for a brief predetermined period of time (e.g., milliseconds) until the one or more projectiles have neared or exited the muzzle of the barrel 16. Travel of the one or more projectiles down the bore 20 of the barrel 16 creates more space in the bore 20 for the pressurized gasses resident in the gas chamber 44 and bore 20 to fill. This allows the gasses inside the gas chamber 44 holding the plunger head 54 in the forward in-battery position to bleed back through the cylinder gas port 46, the gas passageway 48, the barrel gas port 21 and into the bore 20 of the barrel 16. This in turn causes the gas pressure in the gas chamber 44 to diminish or dissipate to the point where the rearward force applied by the cartridge casing to the bolt 24 upon discharge overcomes the forward force applied to the plunger head 54 by the pressurized gasses.

Once the forward pressure on the piston head 54 has sufficiently diminished, the rearward force applied to the bolt 24 by the cartridge casing will cause the bolt assembly 22 to move rearward and cycle the firearm 10. Because the rear end 53 of the rod 52 is secured to the timing block 34 and the timing block 34 is secured to the bolt assembly 22, rearward travel of the bolt assembly 22 also causes the plunger 50 and thus the plunger head 54 to move to the rearward position within the cylinder housing 42 (see FIG. 7). This in turn causes the plunger head 54 to push out some or all of the gas remaining in the gas chamber 44 through the cylinder gas port 46, the gas passageway 48, and the barrel gas port 21 back into the bore 20 of the barrel 16 where the gas can exhaust to the atmosphere once the one or more projectiles have exited the muzzle of the firearm 10.

FIGS. 8-14 depict another embodiment of an AR-pattern firearm with a gas-delayed blowback operating system 80 of the present invention. It should be understood that the embodiment depicted in FIGS. 8-14 is shown with certain components (e.g., a magazine) omitted in order to more clearly depict the operational components of the gas-delayed blowback operating system 10 disclosed herein. Any omitted components are readily identifiable to and well known by those of ordinary skill in the art. The gas-delayed blowback firearm 80 of FIGS. 8-14 is alike to the gas-delayed blowback firearm 10 of FIGS. 1-7 in all aspects of form and function except as subsequently specifically described or depicted in the drawings. For example, firearm 80 is depicted as being chambered for 9 mm cartridges 19*b*. As such, the various components of the firearm 80 are sized and shaped to receive and function with 9 mm cartridges instead of 12-gauge shotshells. Firearm 80 also includes a charging handle 5 instead of bolt knob 28. However, firearm 80 could readily be configured to function with a bolt knob 28 instead of charging handle 5.

The barrel gas port 21 of firearm 80 is defined through an upper portion of the barrel 16 directly adjacent to the chamber 18. This arrangement achieves near immediate pressurization of the gas chamber 44 upon discharge. It also aids in the capture of high pressure gasses to more effectively delay rearward travel of the bolt assembly 22 as the projectile travels down the bore 20. By contract, placement of the aligned gas ports 21, 46 and gas passageway 48 further down the bore 20 of the barrel 16 away from the chamber 18 and toward the muzzle of a firearm can decrease the pressure of gasses which enter the gas chamber by allowing the gasses to expand to fill more of the bore 20 as the projectile nears the muzzle. This in turn can prevent the gas chamber 44 from becoming sufficiently pressurized to delay rearward travel of the plunger 50 and attached bolt assembly 22.

An AR-pattern firearm having a gas-delayed blowback operating system 10 of the invention can be assembled by providing an AR-pattern lower receiver 12, an upper receiver 14, a barrel 16, a bolt assembly 22, a timing block 34, a cylinder housing 42, and a plunger 50. The barrel 16 is secured to the upper receiver 14 such that the barrel gas port 21 is aligned with the gas passageway 48. In some embodiments, the barrel 16 is secured to the upper receiver 14 such that the barrel gas port 21 is coaxially aligned with the gas passageway 48. The cylinder housing 42 is at least partially secured in the recess 36 such that the cylinder gas port 46 is aligned with the gas passageway 48. In some embodiments, the cylinder housing 42 is at least partially secured in the recess 36 such that the cylinder gas port 46 is coaxially aligned with the gas passageway 48. The timing block 34 is secured to the bolt 24. The bolt assembly 22 with timing block 34 secured thereto is arranged in the bolt cavity 38. The plunger 50 is inserted rod portion 52 first into the gas chamber 44 via the open forward end 47 of the cylinder housing 42. The plunger 50 is arranged in the gas chamber 44 such that the rod portion 52 extends rearwardly out of the hole 55 in the cylinder housing 42, through passageway 41, and into the bolt cavity 38 and timing block aperture 37 where the rear end 53 of the rod 52 is secured to form an upper receiver assembly. The upper receiver assembly is then coupled to the lower receiver 12 to form the gas-delayed blowback firearm 10.

In all embodiments disclosed herein, the speed with which the bolt assembly 22 cycles can be controlled by varying the mass of the timing block 34. For example, use

a larger or heavier timing block **34** will slow the cycle rate, whereas use of a smaller or lighter timing block **34** will increase the cycle rate.

The gas-delayed blowback operating system **10** for AR-platform firearms disclosed herein advantageously prevents premature and unsafe extraction of the cartridge casing by delaying extraction until gas pressure in the system drops to safe levels. It also eliminates the need of traditional AR-pattern firearms for a rotating bolt, and thus likewise eliminates the need for locking lugs on the bolt **24**. Eliminating the use of a rotating and locking bolt translates to fewer parts required to cycle the firearm, which simplifies firearm operation and provides appreciable weight and cost savings.

Although embodiments of the present invention have been described in detail, it will be understood by those skilled in the art that various modifications can be made therein without departing from the spirit and scope of the invention as set forth in the appended claims. For example, AR-pattern firearms chambered for other relatively low-pressure cartridges, including but not limited to 0.22, 0.38, 0.380, 0.40, and .45 calibers, 0.410 gauge, and 20-gauge, which also include the gas-delayed blowback operating system disclosed herein are within the scope of the present invention and are covered by the claims.

This written description uses examples to disclose the invention and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

It will be understood that the particular embodiments described herein are shown by way of illustration and not as limitations of the invention. The principal features of this invention may be employed in various embodiments without departing from the scope of the invention. Those of ordinary skill in the art will recognize numerous equivalents to the specific apparatus and methods described herein. Such equivalents are considered to be within the scope of this invention and are covered by the claims.

All of the compositions and/or methods disclosed and claimed herein may be made and/or executed without undue experimentation in light of the present disclosure. While the compositions and methods of this invention have been described in terms of the embodiments included herein, it will be apparent to those of ordinary skill in the art that variations may be applied to the compositions and/or methods and in the steps or in the sequence of steps of the method described herein without departing from the concept, spirit, and scope of the invention. All such similar substitutes and modifications apparent to those skilled in the art are deemed to be within the spirit, scope, and concept of the invention as defined by the appended claims.

Thus, although there have been described particular embodiments of the present invention, it is not intended that such references be construed as limitations upon the scope of this invention except as set forth in the following claims.

What is claimed is:

1. A gas-delayed blowback firearm, comprising:

a lower receiver;

an upper receiver releasably coupled to the lower receiver;

a barrel secured to the upper receiver, the barrel having a cartridge chamber, an axial bore, and a barrel gas port in fluid communication with the bore;

a bolt assembly configured to reciprocate in the upper receiver between a forward in-battery position and a rearward position;

a timing block on the bolt assembly;

a cylinder housing secured in a recess defined in a forward portion of the upper receiver above the barrel, the cylinder housing having an internal gas chamber and a cylinder gas port in fluid communication with the gas chamber;

a gas passageway fluidly communicating the barrel gas port with the cylinder gas port; and

a plunger in the gas chamber secured to the timing block such that the plunger reciprocates with the bolt assembly;

wherein discharge of a cartridge received in the cartridge chamber temporarily pressurizes the gas chamber, applying a forward force to the plunger which causes the plunger to delay rearward travel of the bolt assembly.

2. The firearm of claim **1**, wherein the plunger delays rearward travel of the bolt assembly until the pressure in the gas chamber decreases to a predetermined level whereby a rearward force applied by the cartridge against the bolt assembly overcomes the forward force applied to the plunger and moves the bolt assembly toward the rearward position.

3. The firearm of claim **1**, wherein the plunger includes a first end secured to the timing block and a second end which rests in the gas chamber forward of the cylinder gas port when the bolt assembly is in the forward in-battery position.

4. The firearm of claim **3**, wherein:

the cylinder housing includes a rear end having a hole defined therethrough;

the first end of the plunger extends rearwardly out of the hole in the rear end of the cylinder housing; and

the second end of the plunger includes a plurality of baffles.

5. The firearm of claim **1**, wherein the gas chamber extends axially through the cylinder housing substantially parallel to the bore of the barrel.

6. The firearm of claim **1**, wherein:

the plunger includes a rod portion and a head portion;

the rod portion has a rod diameter;

the head portion has a head diameter;

the head diameter is greater than the rod diameter;

the head portion rests in the gas chamber forward of the cylinder gas port when the bolt assembly is in the forward in-battery position;

the rod portion extends rearwardly from the head portion out of a rear end of the cylinder housing; and

an end of the rod portion opposite the head portion is secured to the timing block.

7. The firearm of claim **1**, wherein the barrel gas port is disposed forward of and adjacent or proximate to the cartridge chamber.

8. The firearm of claim **7**, wherein the barrel gas port, the gas passageway, and the cylinder gas port are substantially vertically aligned.

9. The firearm of claim **7**, wherein the gas passageway is defined through the upper receiver between the barrel gas port and the cylinder gas port.

10. A gas-delayed blowback firearm, comprising:
an AR-pattern lower receiver;
an upper receiver releasably couplable to the lower receiver;
a barrel attachable to the upper receiver, the barrel having a cartridge chamber, an axial bore, and a barrel gas port in fluid communication with the bore;
a bolt assembly receivable in the upper receiver and configured to reciprocate therein between a forward in-battery position and a rearward position;
a timing block attachable to the bolt assembly;
a cylinder housing attachable to the upper receiver, the cylinder housing having an internal gas chamber and a cylinder gas port in fluid communication with the gas chamber
a recess defined in a forward portion of the upper receiver, the recess configured to receive at least a portion of the cylinder housing when the cylinder housing is attached to the upper receiver;
a gas passageway defined through the upper receiver which fluidly communicates the barrel gas port with the cylinder gas port when the barrel and the cylinder housing are attached to the upper receiver; and
a plunger receivable in the gas chamber and attachable to the timing block such that the plunger reciprocates with the bolt assembly when the plunger is attached to the timing block and the timing block is attached to the bolt assembly;
wherein discharge of a cartridge received in the cartridge chamber temporarily pressurizes the gas chamber, applying a forward force to the plunger which causes the plunger to delay rearward travel of the bolt assembly until the pressure in the gas chamber decreases enough for a rearward force applied by the cartridge against the bolt assembly to overcome the forward force applied to the plunger and move the bolt assembly toward the rearward position.

11. The firearm of claim 10, wherein:
the cylinder housing includes a rear end having a hole defined therethrough;
the plunger includes a rod portion which extends rearwardly out the hole in the cylinder housing, and a head portion which rests in the gas chamber forward of the cylinder gas port when the cylinder housing is attached to the upper receiver, the plunger is received in the cylinder housing, the timing block is attached to the bolt assembly, the rod portion of the plunger is attached to the timing block, and the bolt assembly is in the forward in-battery position.

12. The firearm of claim 11, wherein:
the rod portion has a rod diameter;
the head portion has a head diameter;
the head diameter is greater than the rod diameter; and
the head portion includes a plurality of baffles.

13. The firearm of claim 10, wherein the gas chamber extends axially through the cylinder housing substantially parallel to the bore of the barrel when the barrel and the cylinder housing are attached to the upper receiver.

14. A method of assembling the firearm of claim 10, comprising:
providing the upper receiver, the barrel, the bolt assembly, the timing block, the cylinder housing, and the plunger;
attaching the barrel to the upper receiver such that the barrel gas port is aligned with the gas passageway;
securing the cylinder housing in the recess of the upper receiver such that the cylinder gas port is aligned with the gas passageway;
attaching the timing block to the bolt assembly;
arranging the bolt assembly and attached timing block in the upper receiver;
inserting the plunger in the gas chamber of the cylinder housing; and
attaching the plunger to the timing block.

15. An upper receiver assembly for a gas-delayed blowback firearm, comprising:
an upper receiver releasably couplable to an AR-pattern lower receiver;
a barrel attachable to the upper receiver, the barrel having a cartridge chamber, an axial bore, and a barrel gas port in fluid communication with the bore;
a bolt assembly receivable in the upper receiver and configured to reciprocate therein between a forward in-battery position and a rearward position;
a timing block attachable to the bolt assembly;
a cylinder housing attachable to the upper receiver, the cylinder housing having an internal gas chamber and a cylinder gas port in fluid communication with the gas chamber;
a recess defined in a forward portion of the upper receiver, the recess configured to receive at least a portion of the cylinder housing when the cylinder housing is attached to the upper receiver;
a gas passageway defined through the upper receiver which fluidly communicates the barrel gas port with the cylinder gas port when the barrel and the cylinder housing are attached to the upper receiver; and
a plunger receivable in the gas chamber and attachable to the timing block such that the plunger reciprocates with the bolt assembly when the plunger is attached to the timing block and the timing block is attached to the bolt assembly;
wherein discharge of a cartridge received in the cartridge chamber temporarily pressurizes the gas chamber, applying a forward force to the plunger which causes the plunger to delay rearward travel of the bolt assembly until the pressure in the gas chamber decreases such that a rearward force applied by the cartridge against the bolt assembly overcomes the forward force applied to the plunger and moves the bolt assembly toward the rearward position.

16. The upper receiver assembly of claim 15, wherein the cylinder housing includes:
an open forward end through which the plunger is receivable, and
a rear end in which is formed a hole through which a portion of the plunger extends when the plunger is attached to the timing block.

17. The upper receiver assembly of claim 15, wherein the plunger includes a first end configured to be engaged with the timing block and a second end which rests in the gas chamber forward of the cylinder gas port when the cylinder housing is attached to the upper receiver, the plunger is received in the cylinder housing, the timing block is attached to the bolt assembly, the first end of the plunger is engaged with the timing block, and the bolt assembly is in the forward in-battery position.

18. A gas-delayed blowback firearm, comprising an upper receiver assembly of claim 15 coupled to the lower receiver.

19. A method of assembling a gas-delayed blowback firearm, comprising:
providing the lower receiver and an upper receiver assembly of claim 15;
attaching the barrel to the upper receiver such that the barrel gas port is aligned with the gas passageway;

attaching the cylinder housing in the recess of the upper receiver such that the cylinder gas port is aligned with the gas passageway;

attaching the timing block to the bolt assembly;

arranging the bolt assembly and attached timing block in the upper receiver;

inserting the plunger in the gas chamber of the cylinder housing; and

attaching the plunger to the timing block; and

coupling the upper receiver assembly to the lower receiver.

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